IMPACTS OF A HIGHWAY EXPANSION PROJECT ON WOLVES IN NORTHWESTERN WISCONSIN

(Preliminary Findings)

Bruce Kohn
Wisconsin DNR
Rhinelander, WI

Jacqueline Frair
Univ. of Wisconsin
Stevens Point, WI

David Unger
Univ. of Wisconsin
Stevens Point, WI

Thomas Gehring
Univ. of Wisconsin
Stevens Point, WI

Douglas Shelley
Univ. of Wisconsin
Stevens Point, WI

Eric Anderson
Univ. of Wisconsin
Stevens Point, WI

Paul Keenlance
Michigan State University
East Lansing, MI

Abstract

Research was conducted to evaluate the impacts of upgrading 71 km of US Highway 53 (US 53) from 2-lanes into 4-lanes on wolves (*Canis lupus*) in northwestern Wisconsin. Our main objectives were to assess the impacts of the highway project on resident and dispersing timber wolves, and to identify critical habitats and travel corridors for wolves.

FiftyBnine timber wolves (33 males; 26 females) were radio-collared and monitored. Howling surveys were conducted during July-September to determine numbers of pups produced in each known pack. Winter track searches and aerial observations were used to determine the number of wolves in each pack and to detect the presence of newly-established packs. All known wolf mortalities were investigated and recorded.

To date it does not appear that the US 53 highway project negatively impacted resident or dispersing wolves. The resident wolf population within the 7,000 km^2 study area increased from 18 animals in 1994 to 61 wolves in 1999. More than 1/3 of the wolf pack territories in the study area in 1999 were adjacent to the highway construction project. Thirteen of 20 radio-collared dispersing wolves encountered US 53 in their travels and all but one of them crossed it, some several times. Although 10 wolves were killed by vehicles in this study, only 3 of those accidents occurred along US 53. It appeared that dispersing wolves were much more cautious about crossing highways than resident wolves.

Wolves preferred to establish den sites near the center of their territory. Within that inner core they selected for areas with lower road densities, and most dens were dug into steep banks with sandy soils. They appeared to be more tolerant of roads and human disturbance at rendezvous sites than at den sites. Most rendezvous sites were established in lowland habitats within 50 m of a water source

Wolves preferred to cross highways where they bisected large, homogeneous landscapes, especially lowland complexes. Wolf crossings were more likely to occur in areas providing greater visibility and ease of travel. A model was developed to identify "high", "moderate", and "low potential wolf crossing sites" in highway projects.

The full impact of the US 53 construction project on wolves cannot be determined as of yet. Future increases in traffic volume, speed limits, and/or human development along the US 53 corridor could result in more serious impacts than found to date.

Introduction

The gray wolf was considered extirpated from Wisconsin between 1960 and 1975 (Thiel 1978). A pack of wolves was discovered on the Wisconsin-Minnesota border just south of Duluth-Superior during the winter of 1974-75 (Thiel 1993). The Wisconsin Department of Natural Resources (WDNR) then listed wolves as endangered in 1975. The US Fish and Wildlife Service (USFWS) had previously listed wolves as a Federally Endangered Species in 1967.

When the Wisconsin Department of Transportation (WDOT) proposed conversion of a 71 km segment of U.S. Highway 53 (US 53) in northwestern Wisconsin from 2 lanes into 4 lanes (Fig. 1), there was concern that expansion of US 53 could have an impact on the recovery of Wisconsin's wolf population. The US 53 project passed through areas inhabited by wolves and crossed the main dispersal route for wolves coming from Minnesota into Wisconsin.

An AEastern Timber Wolf Biological Assessment for U.S. Highway 53@ was prepared by WDOT (1990). Wolf experts from Wisconsin, Minnesota, and Michigan were solicited to discuss: 1) the importance of maintaining the dispersal corridor for wolves coming from Minnesota into Wisconsin, 2) findings from previous research on the impacts of roads on wolf populations, and 3) modifications to the proposed highway design that might mitigate any negative impacts on wolves.

WDOT incorporated many of the suggestions offered by the panel of wolf experts into the design of US 53. They decided not to place any fences along the highway right-of-way throughout the 71 km segment under construction, and limited private access to the current level to minimize further development. The bridges over the Totogatic River were designed to allow easy under-highway crossings by wolves, and WDOT Aballooned@ the median in 3 sections of the highway known to be wolf crossing areas. In these areas they kept at least 100 m between centerlines of the 2 lanes, maintained existing natural cover in the median strip, and allowed wooded cover to come as close to the highway as engineering standards allowed. The wolf experts felt that these Aballooned areas@ would facilitate wolf crossings of US 53.

The USFWS reviewed the Preliminary Final Environmental Impact for the US 53 proposal and strongly recommended that the WDOT finance a comprehensive study of the impacts of this project on wolves. They felt this would require investigation of wolves immediately prior to construction, during construction, and 2 years after completion of the US 53 project. The WDOT contracted with the WDNR to conduct the research.

The main objectives of this study were: 1) to determine the impacts of the US 53 expansion project on resident and dispersing wolves, 2) to determine the effectiveness of wolf crossing sites incorporated into the highway design, and 3) to develop criteria for identifying/mitigating any negative impacts of future highway projects on wolves. The research began in May 1992.

Unfortunately, construction began on the US 53 highway project early in 1992 before we were able to collect any baseline data. The first section of the project (northernmost 8 km) was completed and open to traffic in 1994 (Fig. 2). Construction was delayed somewhat by weather conditions and permitting problems. At the end of this study (June 1999), 60 km had been completed and the remaining 11 km were scheduled for completion later that year. The posted speed limit on the sections opened to traffic was increased from 55 mph to 65 mph.

The delays in highway construction prevented us from determining the full impacts of the highway project after its completion. Therefore, the following findings must be considered preliminary.

Study Area

This study was conducted in an area of approximately 7,000 km^2 in northwestern Wisconsin (Fig. 3). The study area (US53SA) included all lands west of the US 53 expansion project to the Minnesota border (approximately 40 km), and a strip of land approximately 20 km wide to the east of the highway project. This area is fairly undeveloped. Road densities within the study area range from 0-1.5 km /km^2 (Mladenoff et al. 1995), and most of the land is in county, state, or industrial (paper company) ownership. Although the city of Superior and 2 small (1,900-2,500 residents) towns exist on the highways surrounding the study area, Solon Springs and Minong (populations 500-600) are the only communities within the core of the study area. Logging, recreation, and some agriculture are the primary industries.

The topography in the study area is gentle to strongly rolling. The vegetation is predominantly an interspersion of upland and lowland mixed forests. The upland forest is composed primarily of sugar maple (*Acer saccharum*), basswood (*Tilia americana*), aspen (*Populus tremuloides, P. grandidentata*), paper birch (*Betula papyrifera*), northern red oak (*Quercus rubra*), jack pine (*Pinus Banksiana*), and red pine (*pinus resinosa*). The lowland areas are primarily open bogs, sedge (*Carex spp*.) meadows, or marshes of black spruce (*Picea mariana),* white cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), black ash (*Fraxinus nigra*), and alder (*Alnus rugosa*).

Methods

Wolves were captured, immobilized, processed, and fitted with radio-collars as described by Kohn et al. (1996). All collared wolves were located 1-3 times weekly from fixed-wing aircraft. Wolves residing close to US 53, and dispersing wolves, were monitored more intensively from the ground.

Track searches were conducted during December-March to determine the distribution and numbers of wolves in the study area, to determine the breeding status of each pack (Rothman and Mech 1979) and to locate highway crossings by wolves. Aerial counts were used whenever possible to estimate numbers of wolves in each pack. Howling surveys during July-September were used to determine pup production/survival in each pack (Harrington and Mech 1982). All known wolf mortalities were investigated and necropsies were conducted at the USFWS National Health Laboratory in Madison.

Methods and statistical tests used to measure/evaluate microhabitat and macrohabitat variables within wolf territories, along wolf trails, at den and rendezvous sites, and at wolf highway crossing sites are described in detail by Shelley and Anderson (1995), Gehring (1995), Unger (1999) and Frair (1999). Thorough discussions of the development of models for predicting wolf highway crossing sites and den and rendezvous sites are presented in Unger (1999) and Frair (1999).

Results

<u>Trapping and Monitoring Success</u>

Fifty-nine wolves were captured, fitted with radio collars, and monitored during this study. These included 22 adult, 7 yearling, and 4 pup males and 11 adult, 13 yearling, and 2 pup females. The smaller numbers of pups and adult females captured was due to our reluctance to trap near known den and rendezvous sites during May-July to minimize chances of disturbing family groups.

We prematurely lost or terminated contact with 20 of the 59 collared wolves. These were due to dispersal or translocation off the study area (7 wolves), undetected dispersal or collar failure (6 wolves), suspected "foul play" (6 wolves), and the collar being chewed off 1 wolf by other wolves. Seventeen collared wolves were found dead (*see* "Wolf Populations in the US 53 Study Area"), and the collars expired when expected on 5 wolves.

Only 28 of the 49 wolves captured during 1992-98 provided information for $\geq$ 12 months. And, 1 of the 10 wolves captured this past summer (1999) has already died. Sixteen wolves in 15 packs were being monitored at the end of this study.

Mean home ranges of the radio-collared wolves were 117 km^2 during the "denning and rendezvous" period (April - September), and 189 km^2 during the "nomadic" period (October - March) (Shelley and Anderson 1995). Mean home range sizes did not differ significantly between sexes. Hourly movement rates of wolves during the "nomadic" period showed no distinct time periods during the day when wolves were most mobile.

<u>Wolf Populations in the US 53 Study Area</u>

It took almost 2 years to adequately determine the numbers and distribution of wolves in the large US53SA. Pilot observations, telemetry data, and track searches produced our first, reliable estimate of 18 wolves in 5 established packs in March 1994 (Fig. 4, Table 1). The population increased an average of 28% per year, and we estimated a population of 61 wolves in 16 established packs within the US53SA in March 1999. The increases occurred as wolves expanded their range eastward in the study area (Fig. 5).

Our estimates must be considered conservative because they were based primarily on pilot observations of wolf numbers in established packs. And, we did not include lone, dispersing wolves in the estimates. They were very difficult to census but probably comprised 5-20% of the total wolf population (Fuller 1989).

Seventeen collared wolves were found dead during this study. Five were killed in collisions with vehicles, 4 were shot or snared, 3 died from mange-related complications, 2 were killed by other wolves, 2 died from capture related problems, and 1 died while giving birth. A necropsy has not yet been performed on the collared wolf found dead on August 19, 1999. In addition, 5 uncollared wolves were killed by vehicles in the US53SA and 1 pup was found dead from unknown causes at a den site.

The mean annual survival rate for collared, adult wolves was 81% (n=32). Four of the 6 pups collared lived at least 1year after capture. One died about 1 month after capture when the collar somehow became lodged in its mouth, and we lost contact with the other pup 8 months after its capture.

The population growth rate of 28% per year was higher than the average (20% per year) for all of Wisconsin's wolf range (Wydeven et al. 1999). Pup production and survival, adult survival, and ingress was adequate to allow for this healthy population growth.

<u>Territory Selection</u>

Measurements of road densities have provided the most widely accepted estimates of suitable wolf habitat in the Great Lakes Region (Thiel 1985, Mech et al. 1988, Mladenoff et al. 1995 , Mladenoff et al. 1997). Shelley and Anderson (1995) found that wolves within the US53SA set up territories in areas with total lower road densities than was generally available throughout the study area. The average road density within territories (0.84 km of road/km^2) was significantly less than the average for the whole study area (1.16 km of road/km^2).

Frair (1999) compared differences between road densities within pack territories to those in areas outside of known wolf territories in the US53SA during 1992-96. She found that total road densities was still the best predictor of wolf habitat and that the density of non-highway public roads better explained territory selection than either major or minor highway densities. She estimated potential within-territory tolerance limits of 0.09

km/km^2 for major highways and 0.15 km/km^2 for minor highways. Wolves crossed non-highway public roads in proportion to their occurrence but avoided highways during their regular within-territory movements.

Selection for Den and Rendezvous Sites

Unger (1999) found that spatial location appeared to be the most crucial factor in the selection of den sites by wolves in the US53SA. Wolves selected for the inner 25% isopleth of their annual territory when establishing a den. Eight of the 9 den sites he examined were located within this inner core, and the other den site was located only 200 m from the border of this central area. He postulated that optimal foraging and avoidance of interpack strife were possible reasons for this pattern of selection. Landscape, class, and patch habitat variables were not significant predictors of den site location.

Within the inner core, wolves established dens in areas with lower road densities. This suggested that wolves preferred areas where human disturbance was minimal. Most of the dens were burrows dug into steep banks with sandy soils. Only 2 of 13 dens were located under fallen trees.

Ten rendezvous sites in 9 pack territories were located during this study. Of these, 4 were directly associated with streams, 2 occurred in shrub wetlands, 2 occurred in forested wetlands, and 2 occurred in upland forests.

Rendezvous site selection appeared to be controlled primarily by habitat factors rather than territory boundaries or roads. Wolves established rendezvous sites throughout their territory, not just the inner 25% isopleth as were den sites. Wolves appeared to be more tolerant of roads and human disturbance at rendezvous sites than they were at den sites. Several rendezvous sites were often in the immediate vicinity of a logging road or forest trail, and some were adjacent to heavily-traveled roads.

Wolves selected wetland habitats with close proximity to open water when establishing rendezvous sites. The availability of open water apparently played an important role in their site selection process. Pups are relatively sedentary at rendezvous sites and a permanent source of water at the site would be beneficial to pups for both digestion and hydration. Water may also play a role in temperature regulation during the hot summer months.

Within wetland habitats, wolves selected areas with higher visual obscurity, semi-open canopy, and higher amounts of broad leaf ground vegetation. High dense grasses associated with the semi-open wetland habitats most often resulted in the higher visual obstruction at rendezvous sites. Areas with higher visual obstruction may have been selected to minimize possible conflicts between pups and intruders.

Unger (1999) developed a model from these data to aid in identification of potential wolf rendezvous sites. Backward stepwise logistic regression produced the following model: $Z = 4.9902 - 2.5080*\text{WETLAND MSI} + 0.523*\text{LSIM}$. MSI and LSIM are FRAGSTATS acronyms for Mean Shape Index and Landscape Similarity Index, respectively (McGarigal and Marks 1995). This model predicted 88% of the rendezvous sites correctly and 72% of the associated random sites correctly for an overall classification rate of 73%.

Wolf Crossings of US 53

Precise locations of 37 wolf crossings of US 53 were obtained during this study (Frair 1999) (Fig. 6). Most (76%) of the crossings occurred along 3 stretches of the highway: 1) 3-13 km south of Minong, 2) $\leq$6 km north of the St. Croix River, and 3) 1-9 km north of Solon Springs. The remaining wolf crossings were more dispersed

Twenty-five wolf crossings of other major highways in the US53SA (WI 27, WI 35) were also evaluated to determine habitats used by wolves for crossing highways.

Frair (1999) found that "patch density", an index to human-induced fragmentation, was the most significant and consistent landscape indicator of favorable wolf crossing habitat. Timber sales, agricultural fields, homes, gravel pits, etc broke up the primarily forested landscape into smaller patches. Wolves preferred to cross highways where they bisected large patches of similar habitat, especially lowland complexes. They avoided developed lands, and did not cross highways in areas adjacent to homes, lakes, or large rivers.

Upland forests and open types were used in proportion to their availability. Although lowland complexes were the most preferred crossing habitats, large patches of less-preferred habitat (upland forests, open types) were used because they provided the distance from human activity required by wolves when moving through the landscape.

On a finer scale, wolves preferred areas with greater visibility and ease of travel for highway crossing sites. Visual obscurity at eye level, which could relate to ease of movement as well as visibility, was lower at wolf crossing sites than adjacent habitats. Snow was significantly more compact at crossing sites than expected which can be directly related to ease of movement.

Gehring (1995) found that wolves extensively used man-made roads and trails when traveling within their territories during winter. They selected travel routes with shallower snow depths, greater visibility, and lower stem densities. The man-made roads and trails provided these features. Frair (1999) backtracked 9 trails made by wolves as they approached major highways. Sixteen percent of the total length of the trails followed (20 km) coincided with groomed snowmobile trails, plowed roads, or railroad tracks, 14% coincided with other linear features such as streams, ridgelines, or gas line rights-of-way, and 7% followed deer trails or individual ski/snowmobile tracks. Although highway crossing sites analyzed in this study did not show preferential use of trails when crossing highways, we expect that wolves opportunistically used trails which coincided with their intended direction of movement even if they led them across a highway.

Most (81%) of the instrumented wolf crossings of US 53 during 1992-96 were made by dispersing animals. Wolf crossings of US 53 by dispersers peaked during late October through late December and from late April through early June. Crossings of US 53 by resident wolves were less time specific. Resident wolves appeared to be less particular about where they crossed highways but still generally chose areas that provided greater ease of travel and better visibility.

Frair (1999) developed a model for identifying potential wolf crossing sites along major highways. That model used raster-based FRAGSTATS to compute landscape composition and pattern metrics within 200 ha sampling areas systematically placed every 100 m along US 53. The model assigned Resource Selection Function (RSF) values for each sampling area using the following formula: $\text{RSF} = \exp(-1.0853*\text{WATER} - 0.4295*\text{PD} - 0.2215*\text{URBAN} + 0.0635*\text{LOWLAND})$. In this formula WATER = % of sampling area in open water; PD = patch density; URBAN = % of sampling area in developed land; LOWLAND = % of sampling area in forested or non-forested wetland. Sampling areas with RSF values >3.000 were labeled as "high potential crossing sites", those with values between 0.111 and 3.000 were labeled "moderate potential crossing sites, and those with values <0.111 were considered to have low crossing potential (Fig. 7).

Frair's model worked well for identifying potential wolf crossing sites along US 53. Fifty-nine percent of the known wolf crossings of US 53 occurred in areas labeled as "high potential crossing sites" and 34% occurred in areas labeled as "moderate potential crossing sites". "High" and "moderate potential crossing sites" comprised 20% and 48% of the US 53 corridor being studied. Only 7% of the wolf crossings of US 53 occurred in areas labeled as "low potential crossing sites".

Wolf Use of "Ballooned" Strips and Underpasses

The "ballooned" sections were located in appropriate spots. Eighteen of the 37 known wolf crossing sites along US 53 occurred in "ballooned" areas, and all 3 of the longer ballooned sections fall within or partially overlap areas described as "high probability wolf crossing sites" later in this document. One dispersing wolf used "ballooned" sections to cross the highway at least 6 times. And, one pack established a territory immediately adjacent to one of the "ballooned" sections and occasionally used it to cross the highway.

In 3 cases radio-collared dispersing wolves were monitored continuously when approaching/crossing US 53 at one of the "ballooned" areas. The first wolf remained close to US 53 for 1-2 hours and then trotted across the "ballooned" section during daylight hours. The second wolf remained near the highway for several hours during the daylight and finally crossed after darkness and traffic was reduced. This wolf also crossed the "ballooned" section in a hurry. The third wolf crossed a "ballooned" area without hesitation during daylight hours.

In a few cases we were actually able to watch wolves as they crossed highways. They seemed to easily avoid vehicles coming from only 1 direction but appeared somewhat confused when vehicles were coming from both directions. The "ballooned" sections minimized this problem because wolves encountered only 1 direction of traffic at a time. More recent observations of resident wolves suggest that they have become more accustomed to vehicular traffic and much less wary than dispersers when crossing US 53.

Initially we felt it would be important to maintain cover as close to the road right-of-way as possible and to maintain/establish cover within the median strip in "ballooned" areas to make them more attractive to wolves. We now feel this is unnecessary because wolves have shown a preference for crossing sites which afford them greater visibility.

Regular checks under the Totagatic Bridge showed that deer and coyotes were willing to go under the bridge to cross US 53, but no wolf tracks have been found. No wolf activity was observed under the other bridges/overpasses along US 53 either. The observed use of the underpass by coyotes provided some evidence that the bridge design may provide safe crossing sites for wolves as well. However, we have found 2 wolf crossings of US 53 within 0.4 km of the underpass, 1 within 30 m, and neither used the underpass to cross the highway.

Wolf Mortalities on US 53

Three wolves were killed by vehicles on US 53 during June-October 1998. These included a collared yearling female dispersing from the Frog Creek Pack, and a pup and a yearling male from the Stuntz Brook Pack whose territory included US 53. The dispersing female crossed US 53 at least 7 times during her travels.

All 3 vehicle/wolf collisions occurred in a 4.8 km segment of US 53 starting 4 km south of Minong. US 53 runs through a large block of lowland habitats in this area and it was labeled a "high potential crossing area" by Frair's (1999) model. The highway is "ballooned" through much of this area and 2 of the mortalities occurred in the "ballooned" strip. Four lightly-used forest roads and trails crossed the highway in this segment, and all 3 mortalities occurred near the intersections of the forest roads/trails and US 53.

Although we found 10 wolves killed by vehicles in the US53SA, these 3 were the only documented wolf mortalities on US 53. Continued monitoring of wolf mortalities on US 53 will be necessary to document any increases in wolf-vehicle collisions as posted speed limits and traffic volume increase.

Impacts on Wolf Recovery

We have found no evidence that the US 53 expansion project has had a serious, negative impact on numbers of resident wolves (members of established packs) or the quality of wolf habitat adjacent to the highway. The resident wolf population within the US53SA more than tripled while US 53 was undergoing construction

The distribution of new packs within the US53SA also suggested that the US 53 expansion project did not deteriorate the quality of adjacent wolf habitat. Eleven new pack territories were established during this study as construction took place. Seven of them were located immediately adjacent to US 53, and 2 of those included US 53 within their territory (Fig.4). It appeared that wolves often used the highway as a boundary between territories. US 53 formed the apparent physical boundary between 6 pack territories in 1999.

The expansion of US 53 from 2 lanes to 4 lanes undoubtedly removed some suitable wolf habitat. But, that loss was minimal because the expansion basically followed the old highway alignment. Highway projects following new alignments through wolf habitat could have a much more significant impact.

Data were collected from 20 dispersing radio-collared wolves during this study. Thirteen of the dispersers (12 females; 1 male) encountered US 53 in their travels. All but 1 of them crossed it; several of them numerous times. Two of them, including the one that didn't cross US 53 while dispersing, established new territories adjacent to the highway and crossed US 53 occasionally after that. Nine of these wolves attained alpha status either by acceptance into an existing pack or through establishment of a new pack, 1 was killed while dispersing, and we lost contact with the other 3 before we could determine their fate.

It does not appear that the US 53 Expansion Project has acted as a significant barrier to dispersing wolves. There has been considerable interchange of wolves between Minnesota and Wisconsin. However, one dispersing wolf was killed by a vehicle while crossing US 53), and some remained in the vicinity of that highway for several hours before crossing. Increased traffic volume and human development on US 53 could change this picture.

Conclusions

The US 53 expansion project bisected the major travel corridor for wolves dispersing from Minnesota into Wisconsin (Kohn et al. 1995, Mech et al. 1995). Mladenoff et al. (1995) felt that preserving the integrity of this travel corridor was a key factor for the successful maintenance of the wolf population in the Great Lakes Region. Population viability analyses by Rolley et al. (1999) suggested that continued immigration of wolves from Minnesota greatly enhanced the probabilities of maintaining a wolf population in Wisconsin.

To date we have found no evidence that the US 53 expansion project has acted as a barrier to dispersing wolves. Thirteen dispersing radio-collared wolves encountered US 53 during this study and all but 1 crossed it. Three of them crossed US 53 multiple times in their travels. All of the dispersers we were able to follow for more than 1 year eventually established new territories and became the dominant animals in those new packs.

The resident wolf population in the US53SA more than tripled while US 53 was undergoing construction. The US 53 highway expansion project has not had a significant impact on resident wolf numbers or distribution. It appears likely that wolves can continue to prosper in the study area with continued public acceptance and adequate protection.

However, the full impact of the highway expansion project on resident and dispersing wolves cannot be determined until it has been completed and in full use. Three wolves were killed by vehicles while crossing US 53, and it seems inevitable that more wolves will be killed by vehicles as their population increases, as more resident packs become established adjacent to the highway, and if/when traffic volume increases substantially on the highway. It will be important to closely monitor future wolf mortalities on US 53 to determine if they represent greater proportions of the wolf population or if they are reducing the influx of new wolves from Minnesota.

The US 53 expansion project involved adding 2 lanes to an existing highway. Rerouting or creating new highways through wolf habitat could result in more significant problems unless considerations are given to wolf den and rendezvous sites and "high potential crossing sites". We found a potential tolerance limit of 0.09 km/km^2 of major highways within wolf territories. Exceeding that level may result in making those areas unsuitable wolf habitat. Finally, more research is needed to evaluate the impacts of highway construction projects which result in traffic volumes greatly exceeding that currently on US 53 (4,700 vehicles/day in 1996).

Results from this study regarding wolf den and rendezvous site selection and highway crossing sites should help managers identify potential sensitive areas in future highway projects going through similar topography. Applying these models will require GIS coverages of habitat types, streams, rivers, lakes, existing roads, and human developments. These coverages are now available for most areas. Identifying potential den sites will also require adequate knowledge of the distribution of wolves in the area of concern. This will require substantial investment of time and money in the form of radio telemetry efforts or intensive track searches.

Ideally these data collections and analyses will be completed before a final highway alignment is decided upon. Avoiding potential den and rendezvous sites normally will require only a few, if any, minor changes in preferred highway alignment. Identification of potential highway crossing sites will delineate areas where features such as box culverts, underpasses, hydrological bridge extensions, and "ballooned" strips may be considered to facilitate wolf crossings of the highway.

We were not able to determine if the "ballooned" areas along US 53 actually facilitated wolf crossings of the highway. The small number of documented wolf crossings of US 53 obtained during this study prevented determination of any survival benefits from the "ballooned" areas. Wolves definitely used these areas to cross US 53, but this was expected because they were placed in areas thought to be wolf crossing sites. The "ballooned" areas may have provided some protection to the wolves because they encountered vehicles coming from only 1 direction at a time.

Acknowledgements

WDNR pilots Phil Miller, Fred Krueger, Dan Kallenbach, Joe Sprenger, and John Bronson made outstanding efforts to locate the radio-collared wolves twice each week during this study. James Ashbrenner (WDNR, Bureau of Integrated Science and Services) and Adrian Wydeven and Ron Schultz (WDNR, Bureau of Endangered Resources) provided continuing support, advice, and assistance whenever requested. Volunteers Rebecca Montgomery, Michelle Lassige, Alexa Spivy, Lorrie Kohn and Kelly Jones provided valuable assistance in our trapping, monitoring, howling, and tracking efforts throughout the years. The authors would also like to thank personnel at the WDNR Ranger Station in Gordon, the WDNR Mechanics Shop in Spooner, and the Burnett, Douglas, and Washburn County Forestry Departments for their support, cooperation, and public relations efforts in our behalf. Michele Parara prepared the graphics for this manuscript and for my presentation at this Conference.

This research was supported in part by the Wisconsin Department of Transportation and Pittman-Robertson W-141-R.

References Cited

Frair, J.L. 1999. Crossing paths: gray wolves and highways in the Minnesota-Wisconsin border region. University of Wisconsin - Stevens Point M.S. thesis. 56pp.

Fuller, T.K. 1995. Guidelines for gray wolf management in the northern Great Lakes Region. International Wolf Center Technical Publication #271. 19pp.

Gehring, T.M. 1995. Winter wolf movements in northwestern Wisconsin and east-central Minnesota: a quantitative approach. University of Wisconsin - Stevens Point M.S. thesis. 132pp.

Harrington, F.H. and L.D. Mech. 1982. An analysis of howling response parameters useful for wolf pack censusing. Journal of Wildlife Management 46:686-693.

Kohn, B.E., D.P. Shelley, T.M. Gehring, D.E. Unger, and E.M. Anderson. 1995. Impacts of highway development on northwestern Wisconsin timber wolves. Wisconsin Department of Natural Resources Research Report. 17pp.

Kohn, B.E, J.E. Ashbrenner, J.L. Frair, D.E. Unger, D.P. Shelley, T.M. Gehring, and E.M. Anderson. 1996. Impacts of highway development on northwestern Wisconsin timber wolves - 1995. Wisconsin Department of Natural Resources Annual Progress Report. 21pp.

McGarigal, K. and B.J. Marks. 1995. FRAGSTATS: spacial pattern analysis program for quantifying landscape structure. General Technical Report PNW-GTR-351. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, Corvallis, Oregon USA.

Mech, L.D., S.H. Fritts, G.L. Radde, and W.J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin 16:85-87.

Mech, L.D., S.H. Fritts, and D. Wagner. 1995. Minnesota wolf dispersal into Wisconsin and Michigan. American Midland Naturalist 133.

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the Northern Great Lakes Region. Conservation Biology 9:279-294.

Mladenoff, D.J., R.G. Haight, T.A. Sickley, and A.P. Wydeven. 1997. Causes and implications of species restoration in altered ecosystems: A spatial landscape project of wolf population recovery. Bioscience 47(1):21-31.

Rothman, R.J. and L.D. Mech. 1979. Scent marking in lone wolves and newly formed pairs. Animal Behavior 17:750-760.

Rolley, R.E., A.P. Wydeven, R.N. Schultz, R.T. Thiel, and B.E. Kohn. 1999. Wolf viability analysis. Pp 40-44 *in* Wisconsin wolf management plan - August 25, 1999. Wisconsin Department of Natural Resources. 69pp.

Shelly, D.P. and E.M. Anderson. 1995. Impacts of US Highway 53 expansion on timber wolves - B*aseline Data*. University of Wisconsin - Stevens Point Final Report. 32pp.

Thiel, R.P. 1978. The status of the timber wolf in Wisconsin, 1975. Transactions Wisconsin Academy Science, Arts and Letters 66:186-194.

Thiel, R.P. 1985. Relationship between road densities and wolf habitat suitability in Wisconsin. American Midland Naturalist 113:404-407.

Unger, D.E. 1999. Timber wolf den and rendezvous site selection in northwestern Wisconsin and east-central Minnesota. University of Wisconsin M.S. thesis. 76pp.

Wisconsin Department of Transportation. 1990. Eastern timber wolf biological assessment for U.S. Highway 53. Federal Project F 018; I.D. 1198-01-01/02. 39pp.

Wydeven, A.P., J.E. Wiedenhoeft, B.E. Kohn, R.P. Thiel, R.N. Schultz, and S.R. Boles. 1999. Wolf population monitoring in Wisconsin for the period October 1998 - March 1999. Wisconsin Department of Natural Resources Progress Report. 24pp.

Table 1. Established wolf packs in the US Hwy 53 Wolf Study Area, 1994-99.

NUMBERS OF WOLVES IN EACH PACK

PACK NAME19941995199619971998 1999

Buckley Creek23
Chain Lakes23
Chases Brook22244
Crex Meadows354332
Crotte Creek6371074
Empire North365656
Empire South24
Frog Creek25
Moose Lake245344
Moose Road3353
Riverside232
Sanctuary24
Shoberg Lake247
Stuntz Brook22555
Tranus Lake 2 2
Truck Trail483733

Total Wolves	18	30	31	45	53	61

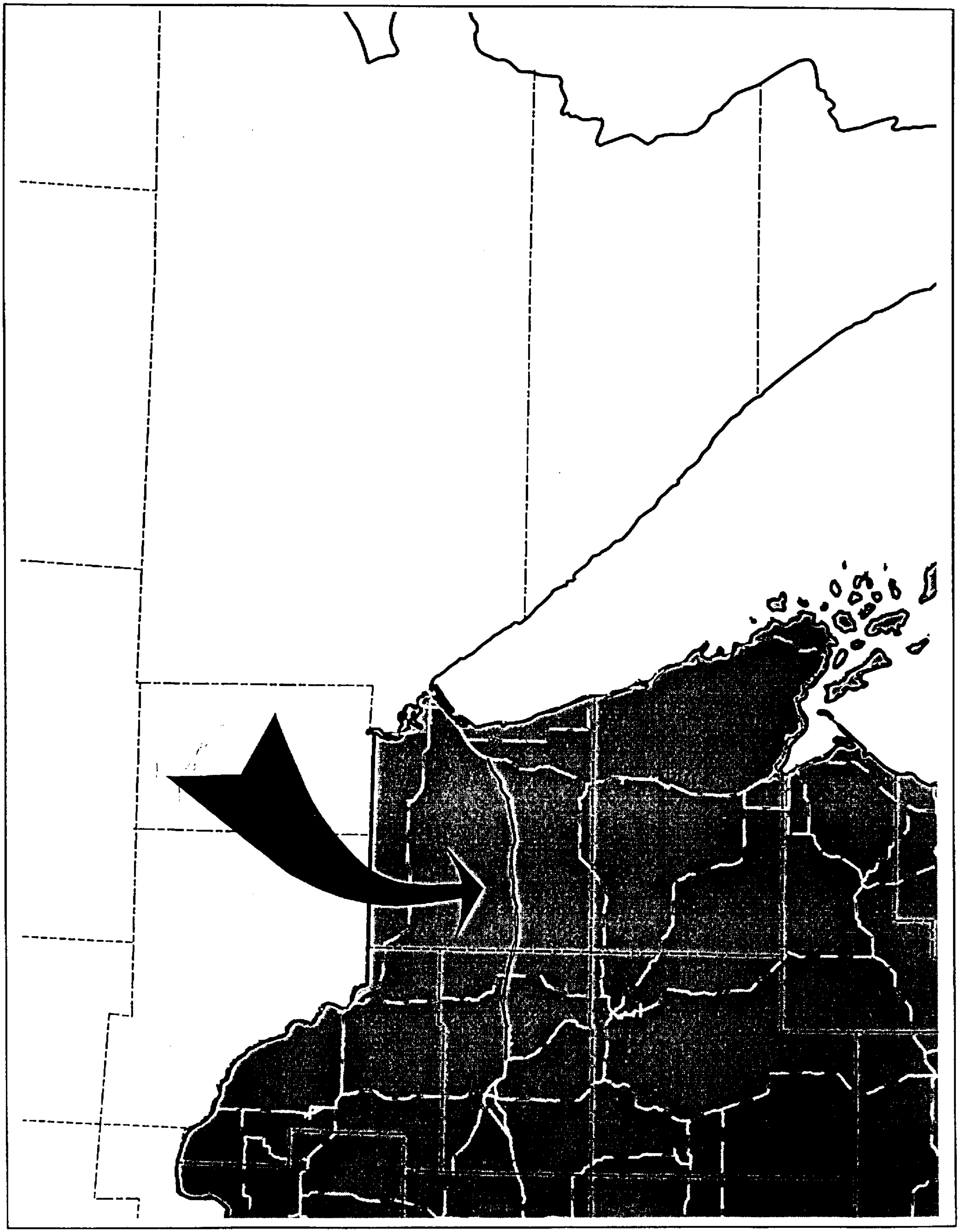

Figure 1. Location of the US Hwy 53 Expansion Project. This project bisected the main travel corridor for wolves coming from Minnesota to Wisconsin.

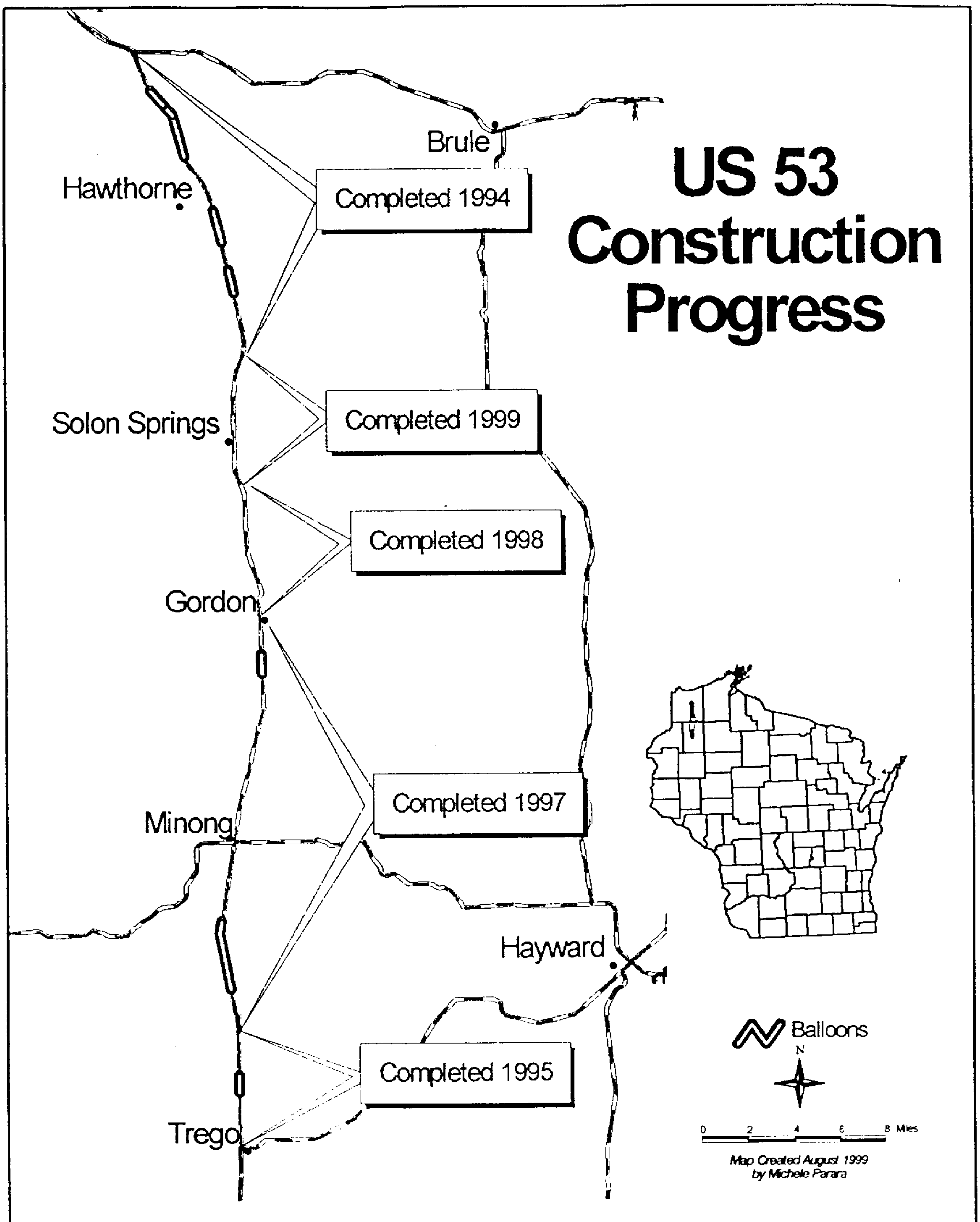

Figure 2. Construction progress in the US Hwy 53 Expansion Project.

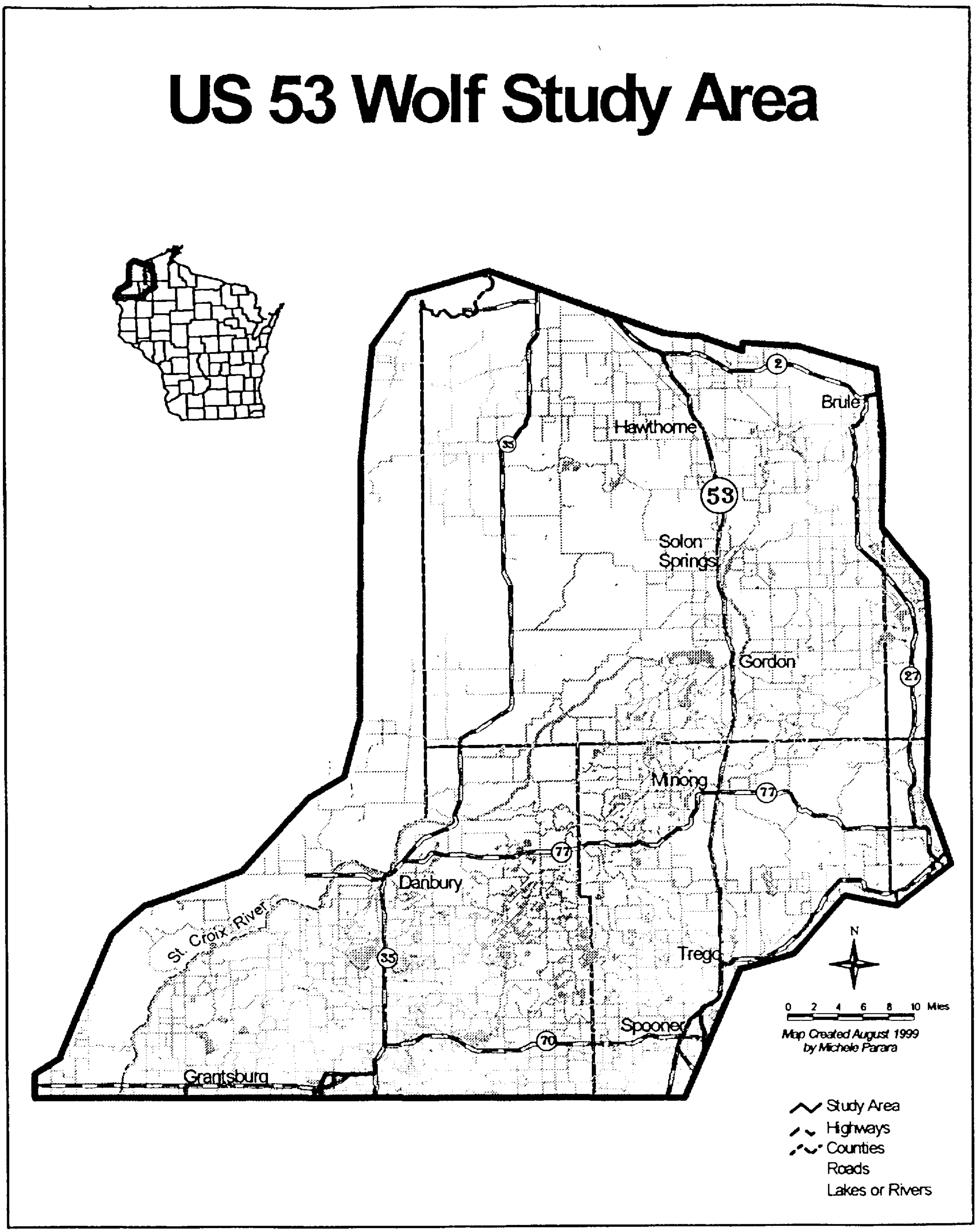

Figure 3. Location of the US Hwy 53 Wolf Study Area.

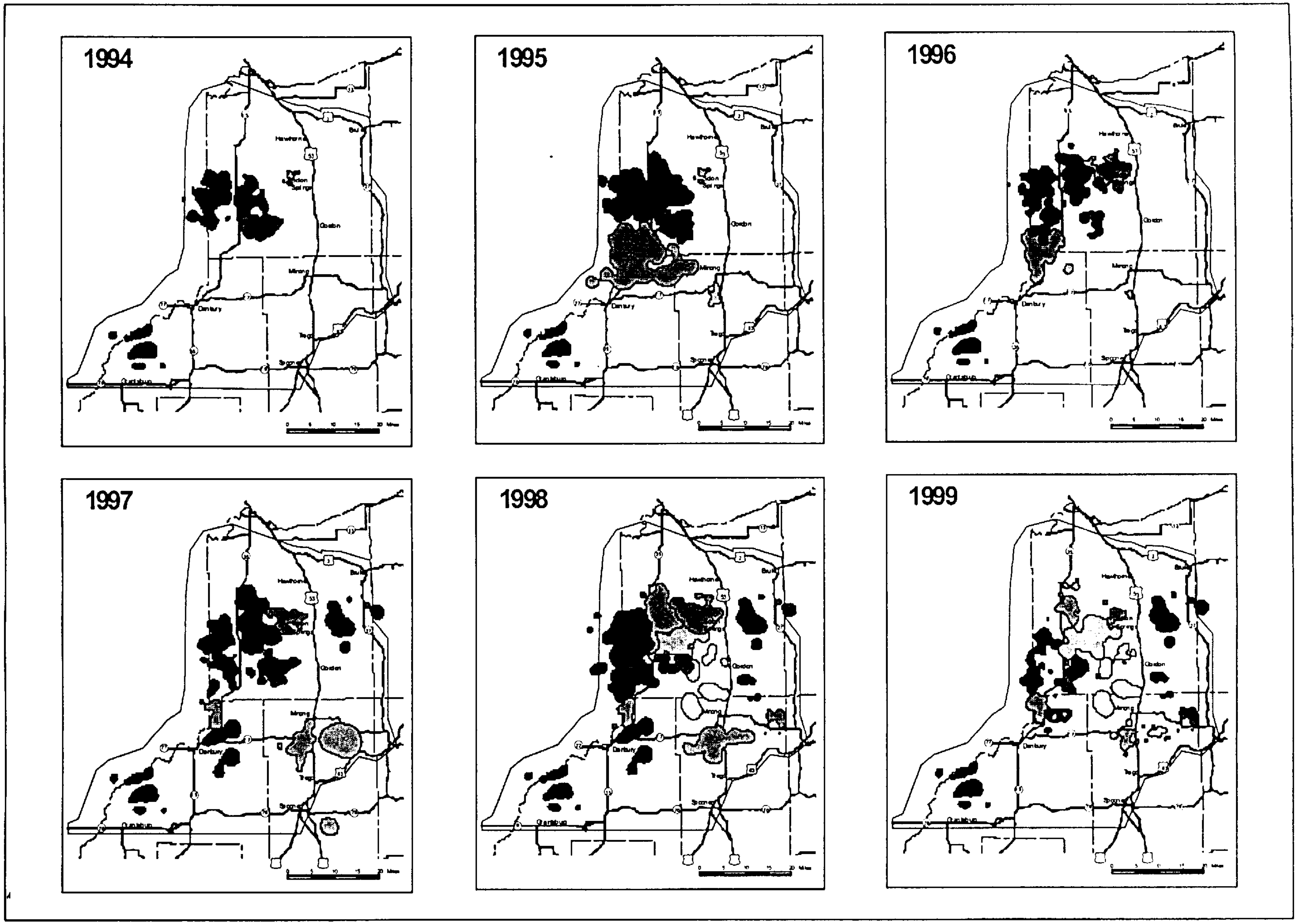

Figure 4. Established wolf pack territories in the US Hwy 53 Wolf Study Area 1994-99. The population increased from 18 wolves in 5 packs to 61 wolves in 16 packs while construction was taking place on Hwy 53.

Table 1. Established wolf packs in the US Hwy 53 Wolf Study Area, 1994-99.

PACK NAME	NUMBERS OF WOLVES IN EACH PACK					
	1994	1995	1996	1997	1998	1999
Buckley Creek					2	3
Chain Lakes					2	3
Chases Brook		2	2	2	4	4
Crex Meadows	3	5	4	3	3	2
Crotte Creek	6	3	7	10	7	4
Empire North	3	6	5	6	5	6
Empire South					2	4
Frog Creek					2	5
Moose Lake	2	4	5	3	4	4
Moose Road			3	3	5	3
Riverside				2	3	2
Sanctuary					2	4
Shoberg Lake				2	4	7
Stuntz Brook		2	2	5	5	5
Tranus Lake				2		2
Truck Trail	4	8	3	7	3	3
Total Wolves	18	30	31	45	53	61

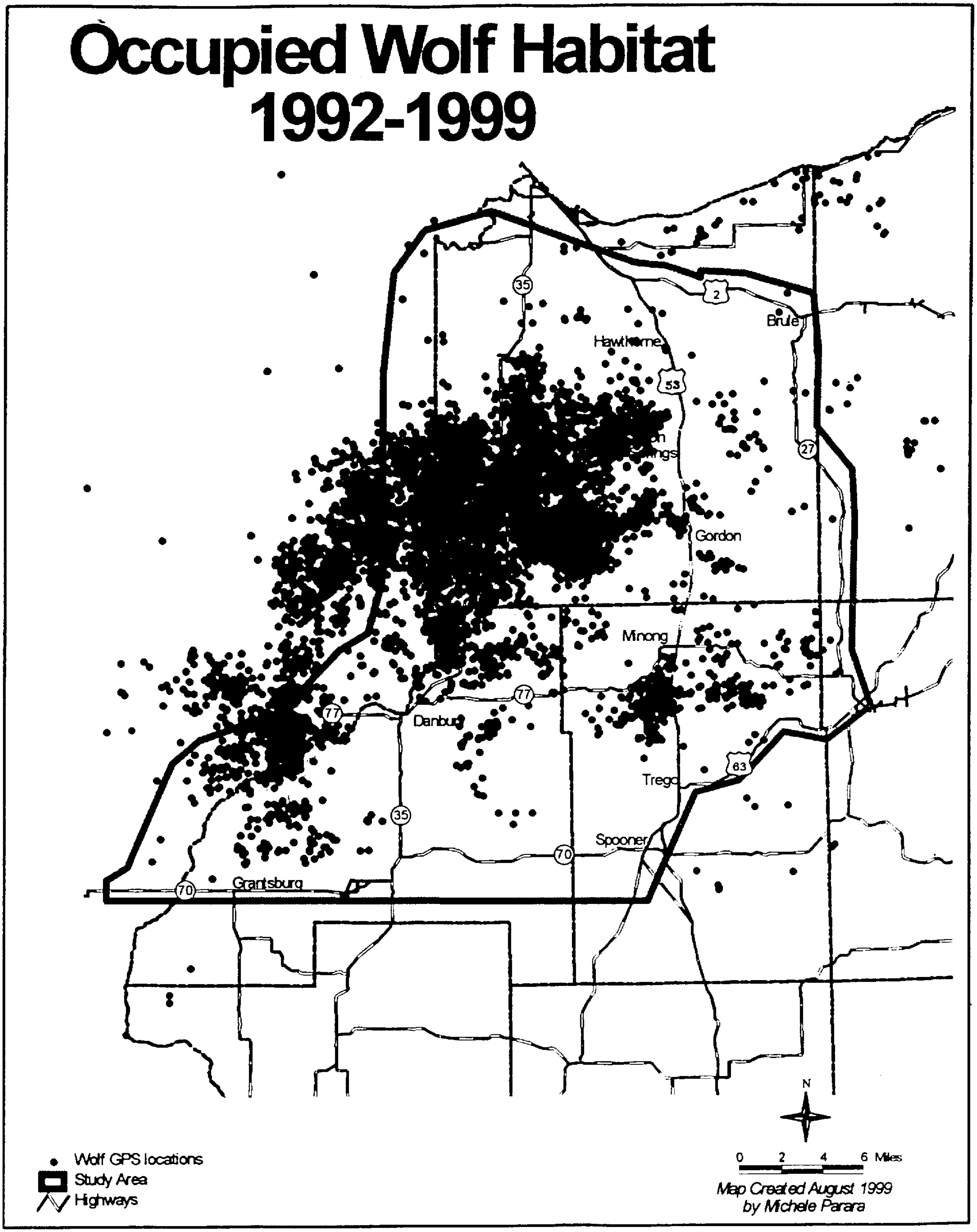

Figure 5. Occupied wolf range in the US Hwy 53 Study Area, 1992-1999

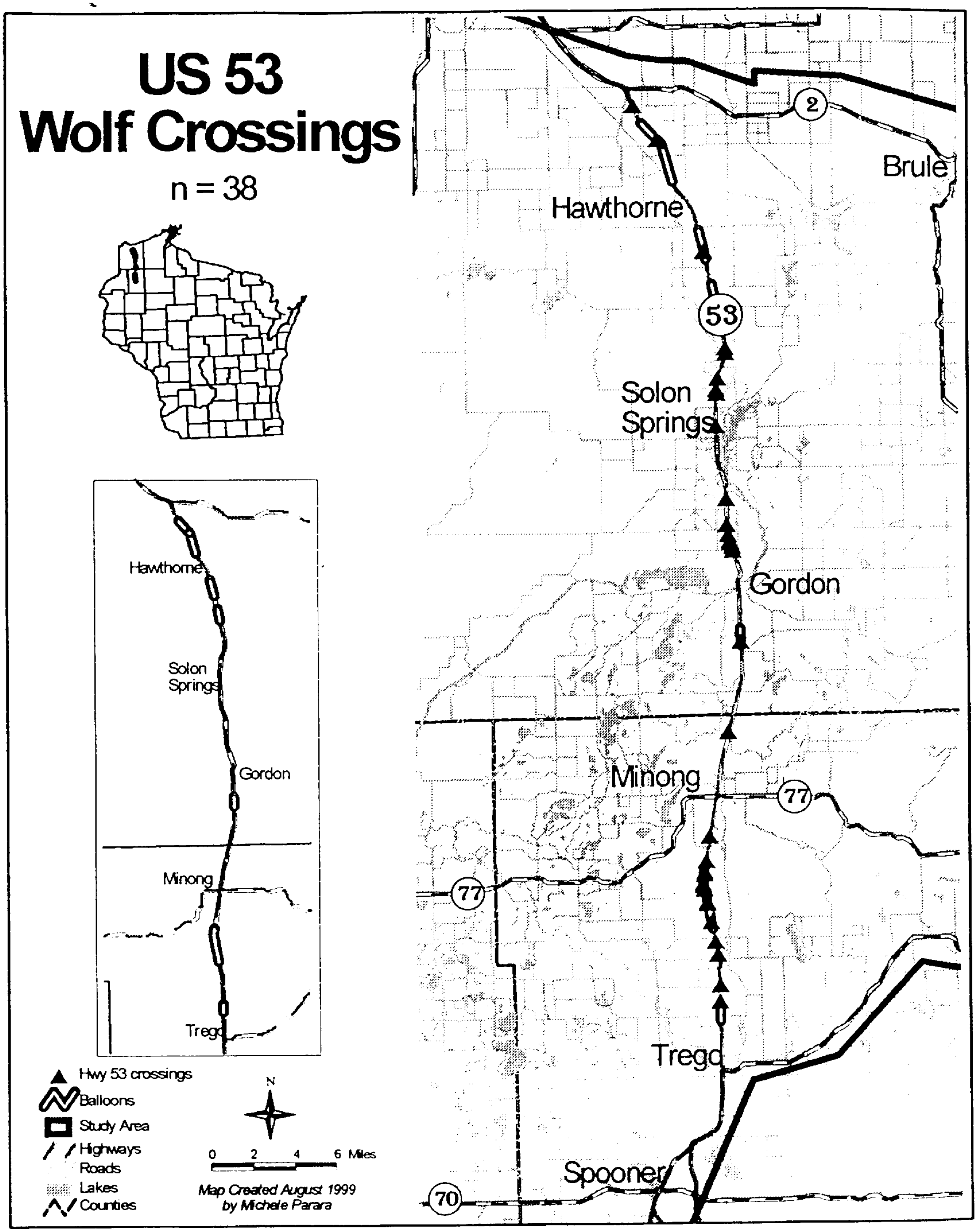

Figure 6. Locations of wolf crossings of US Hwy 53, 1992-99. Almost 50% of the wolf crossings occured in the "balloned" strips.

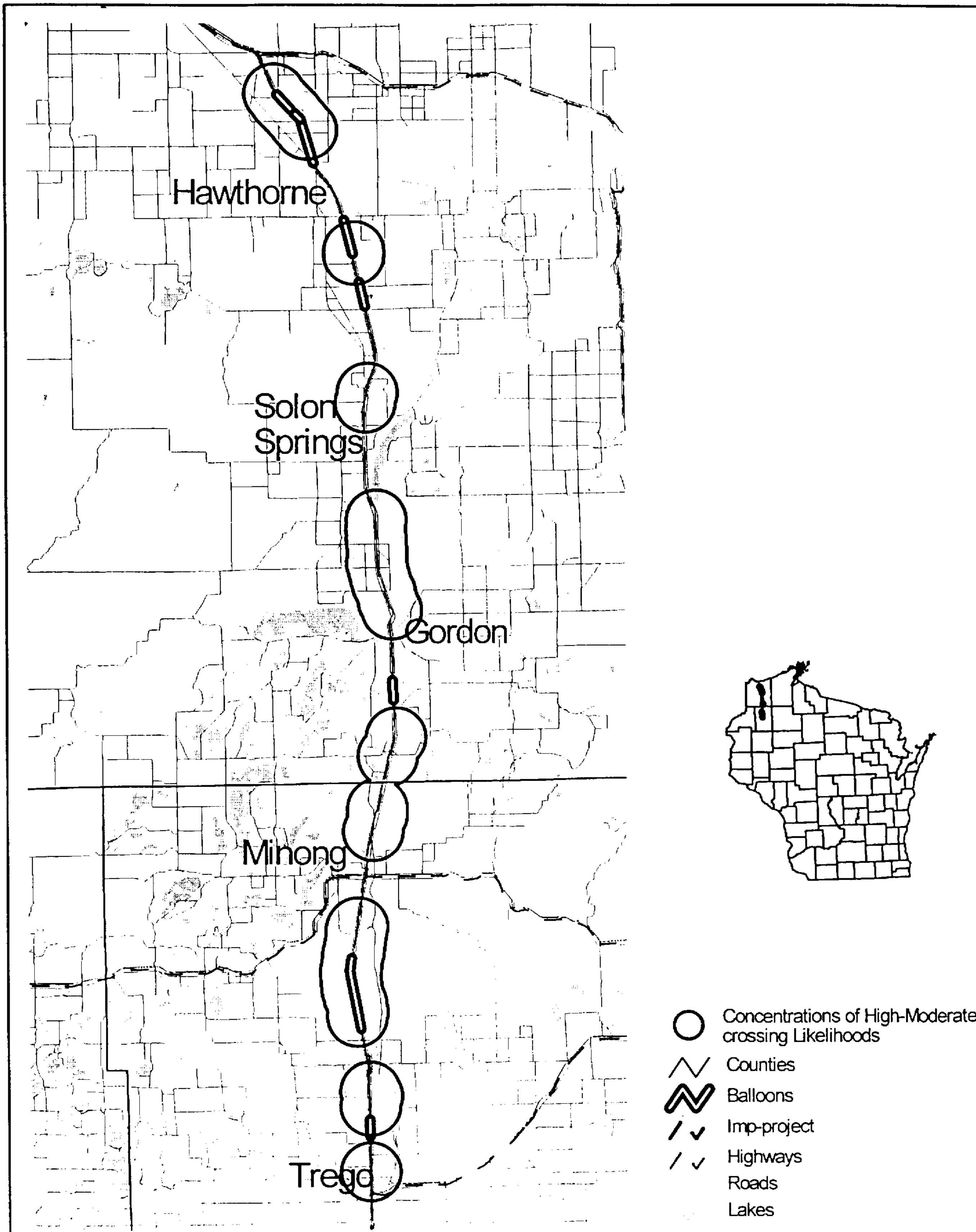

Figure 7. High probability wolf crossing sites of US 53 as determined by the predictive model.